VERIFICATION OF TRANLATION

I, Keiko HOSHINO,

of c/o Miyoshi International Patent Office, Toranomon Kotohira Tower, 2-8, Toranomon 1-chome, Minato-ku, Tokyo 105-0001, Japan,

do hereby declare that I have through knowledge of the Japanese and English languages and that the writing contained in the following pages is a correct translation of the Japanese Patent Office Certificate bearing the file reference

Japanese Patent Application No. 2003-100376
Japanese Patent Application No. 2003-103477
Japanese Patent Application No. 2003-103624

Declared at Tokyo, Japan
This 4th day of September, 2007

Keiko Hoshino

Keiko HOSHINO

P2003-100376 (April 03, 2003, Japan)

[Name of Document] Description

[Title of the Invention] POLISHING PAD, PRODUCTION METHOD THEREOF, AND POLISHING METHOD BY USING THE SAME

[Claims]

[Claim 1]

A polishing pad, comprising a fiber including an organic fiber and a matrix resin holding the fiber, wherein at least the organic fiber is exposed on the work material-sided surface of the polishing pad and the matrix resin contains at least one thermoplastic resin.

[Claim 2]

The polishing pad according to Claim 1, wherein the matrix resin is a semicrystalline thermoplastic resin.

[Claim 3]

The polishing pad according to Claim 1 or 2, wherein an elastomer is dispersed in the matrix resin.

[Claim 4]

The polishing pad according to Claim 3, wherein the glass transition point of the elastomer is 0°C or lower.

[Claim 5]

The polishing pad according to any one of Claims 1 to 4, wherein the organic fiber is an aromatic polyamide.

[Claim 6]

The polishing pad according to any one of Claims 1 to 5, wherein the content of the organic fiber is 1 to 50 wt%.

[Claim 7]

The polishing pad according to any one of Claims 1 to 6, wherein the diameter of the organic fiber is 1 mm or less.

[Claim 8]

The polishing pad according to any one of Claims 1 to 7, wherein the length of the organic fiber is 1 cm or less.

[Claim 9]

The polishing pad according to any one of Claims 1 to 8, wherein the polishing particles are held by the organic fiber exposed on the work material-sided surface.

[Claim 10]

A method of producing a polishing pad used for flattening the surface of a working material as it is bonded to a polishing table, comprising a step of mixing a fiber containing an organic fiber with a matrix composition containing a thermoplastic resin composition to give a mixture, a step of tabletizing the mixture, and a step of converting the tablets into sheet shape by extrusion molding.

[Claim 11]

A method of producing a polishing pad used for flattening the surface of a working material as it is bonded to a polishing table, comprising a step of mixing a fiber containing an organic fiber with a matrix composition containing a thermoplastic resin composition to give a mixture, a step of tabletizing the mixture, and a step of converting the tablets into sheet shape by injection molding.

[Claim 12]

The method of producing a polishing pad according to Claim 10 or 11, further comprising a step of exposing the fiber on the surface.

[Claim 13]

A polishing method, comprising pressing the polishing surface of a base material to the organic fiber-exposed face of the polishing pad according to any one of Claims 1 to 9, supplying a polishing slurry between the polishing surface and the pad, and sliding the base material and the polishing pad relatively to each other.

[Claim 14]

The polishing method according to Claim 13, wherein at least part of a single- or multi-layered metal film is removed by polishing.

[Claim 15]

A polishing method, comprising a first polishing step of polishing at least a metal layer in a substrate having an interlayer insulation film consisting of convex area and concave area, a barrier conductor layer covering the interlayer insulation film along the surface, and the metal layer filling the concave area and covering the barrier conductor layer and thus exposing the barrier conductor layer in the convex area, and a second polishing step of polishing at least the barrier conductor layer and the metal layer in concave area and exposing the interlayer insulation film in the convex area after the first polishing step, wherein the polishing pad according to any one of Claims 1 to 9 is used in polishing at least in the second

polishing step.

[Claim 16]

The polishing method according to Claim 15, wherein the dielectric constant of the interlayer insulation film is 2.7 or less.

[Detailed Description of the Invention]

[0001]

[Technical Field to Which the Invention Belongs]

The present invention relates to a precision polishing pad used, for example, in chemical mechanical polishing (CMP) during production of semiconductor elements and in production of hard disks and a polishing method using the same.

[0002]

[Prior Art]

In the current tread toward increase in packaging density of ultra-large-scale integrated circuit, various microfabrication technologies are now under research and development. The design rule is already in the sub-half micron order. One of the technologies under development satisfying the strict requirements in microfabrication is CMP (chemical mechanical polishing) technology. The technology is effective in flattening the layer to be exposed to light completely, alleviating the load on light exposure technology. Thus, CMP is an indispensable tool, for example, for flattening of interlayer-insulating and BPSG films, shallow trench isolation, and others. Polishing pads commonly used in the CMP method are,

for example, formed urethane resin sheets having concentric or grid-patterned trenches. Although Al wire has been used in the wiring process, embedded wiring by the dual damascene process, which uses Cu, a metal lower in resistivity, as the wiring metal and a low-dielectric constant material as the interlayer insulating film, is the current mainstream process.

[0003]

In the dual damascene process, it is quite important to select a polishing solution and a polishing pad adequately. In particular, the metal, which is more chemically reactive and softer than the interlayer insulating film, often causes defects by polishing scratch and corrosion. On the other hand, dishing occurs more frequently on the material easily deformed or smaller in elastic modulus and rigidity. Accordingly, a polishing cloth improved in pad rigidity was proposed (see Patent Document 1).

[0004]

[Patent Document 1] Japanese Patent Application Laid-Open No. 2001-198797

[0005]

[Problems to be Solved by the Invention]

However, increase in pad rigidity may cause defects such as polishing scratch.

In addition, recent application of a low-dielectric constant material to the interlayer insulating film is accompanied by deterioration in the mechanical properties of the insulation layer and also in the adhesion thereof with metal, causing defects during polishing, and thus, there is a need for

a polishing system demanding smaller mechanical load during polishing.

The present invention provide a polishing pad that is superior in flatness, demands smaller load and allows polishing without defects in the insulation layer, when used in the CMP method, by which wiring is formed by embedding and growing a metal film into a trench pattern formed on an interlayer insulation film and flattening the metal film by polishing, and a polishing method using the same.

[0006]

[Means for Solving the Problems]

The present invention was made, based on the finding that a CMP polishing pad having an ultra-thin fiber layer on the surface of an elastomer allows polishing of a wiring metal at low load and reduce generation of polishing scratches during CMP of the circuit-forming process by the dual damascene method.

[0007]

Thus, the present invention relates to the followings:

(1) A polishing pad, comprising a fiber including an organic fiber and a matrix resin holding the fiber inside, wherein at least the organic fiber is exposed on the work material-sided surface of the polishing pad and the matrix resin contains at least one thermoplastic resin.

[0008]

(2) The polishing pad described in (1), wherein the matrix resin is a semicrystalline thermoplastic resin.

(3) The polishing pad described in (1) or (2), wherein

an elastomer is dispersed in the matrix resin.

(4) The polishing pad described in (3), wherein the glass transition point of the elastomer 0°C or lower.

[0009]

(5) The polishing pad described in any one of (1) to (4), wherein the organic fiber is an aromatic polyamide.

(6) The polishing pad described in any one of (1) to (5), wherein the content of the organic fiber 1 to 50 wt%.

(7) The polishing pad described in any one of (1) to (6), wherein the diameter of the organic fiber is 1 mm or less.

(8) The polishing pad described in any one of (1) to (7), wherein the length of the organic fiber 1 cm or less.

(9) The polishing pad described in any one of (1) to (8), wherein the polishing particles are held by the organic fiber exposed on the work material-sided surface.

[0010]

(10) A method of producing a polishing pad used for flattening the surface of a working material as it is bonded to a polishing table, comprising a step of mixing a fiber containing an organic fiber with a matrix composition containing a thermoplastic resin composition to give a mixture, a step of tabletizing the mixture, and a step of converting the tablets into sheet shape by extrusion molding.

(11) A method of producing a polishing pad used for flattening the surface of a working material as it is bonded to a polishing table, comprising a step of mixing a fiber containing an organic fiber with a matrix composition containing

a thermoplastic resin composition to give a mixture, a step of tabletizing the mixture, and a step of converting the tablets into sheet shape by injection molding.

(12) The method of producing a polishing pad described in (10) or (11), further comprising a step of exposing the fiber on the surface.

[0011]

(13) A polishing method, pressing the polishing surface of a base material to the organic fiber-exposed face of the polishing pad described in any one of (1) to (9), supplying a polishing slurry between the polishing surface and the pad, and sliding the base material and the polishing pad relatively to each other.

(14) The polishing method described in (13), wherein at least part of a single- or multi-layered metal film is removed by polishing.

(15) A polishing method, comprising a first polishing step of polishing at least a metal layer in a substrate having an interlayer insulation film consisting of concave area and convex area, a barrier conductor layer covering the interlayer insulation film along the surface, and the metal layer filling the concave area and covering the barrier conductor layer and thus exposing the barrier conductor layer in the convex area, and a second polishing step of polishing at least the barrier conductor layer and the metal layer in concave area and exposing the interlayer insulation film in the convex area after the first polishing step, wherein the polishing pad described in (1) to

(9) is used in polishing at least in the second polishing step.

(16) The polishing method described in (15), wherein the dielectric constant of the interlayer insulation film is 2.7 or less.

[0012]

[Mode for Carrying out the Invention]

The structure of the polishing pad according to the present invention is not particularly limited, if the organic fiber is exposed on the polishing face-sided surface at least during use.

[0013]

The matrix resin holding the fiber for the pad according to the present invention is not particularly limited, if it contains at least one thermoplastic resin, preferably if it contains a thermoplastic resin as its principal component. Preferably, it is a thermoplastic resin having a room-temperature elastic modulus of 0.1 GPa or more, more preferably 0.5 GPa or more. A smaller elastic modulus leads to deterioration in flatness. Examples of the thermoplastic resins include polycarbonate, polymethyl methacrylate, AS (acrylonitrile-styrene copolymers), ABS (acrylonitrile-butadiene rubber-styrene copolymers), polyethylene, polypropylene, polybutene, 4-methyl-pentene-1, ethylene-propylene copolymers, ethylene vinyl acetate copolymers, polyester, polyamide, polyamide-imide, polyacetal and the like. These resins may be used alone or in combination of two or more resins, and in particular, use of a semicrystalline thermoplastic resin as the matrix resin is effective in giving

a polishing pad superior in abrasion resistance and higher in durability.

[0014]

In addition to the thermoplastic resins above, a crosslinked or uncrosslinked elastomer, crosslinked polystyrene, crosslinked polymethyl methacrylate, or the like may be added as an additive to and dispersed in the matrix resin. Addition of a thermoplastic elastomer and a low-crosslinked elastomer is more preferable. The elastomer is not particularly limited, if it has a glass transition point not higher than room temperature, and preferably has a glass transition temperature of 0°C or lower. Examples thereof include olefinic elastomers, styrene-based elastomers, urethane-based elastomers, ester-based elastomers, elastomers of an alkenylaromatic compound-conjugated diene copolymer or a polyolefin-based copolymer, and the like. Increase in the addition amount of the elastomer leads to a tough resin higher in impact resistance and also to increase in the friction force between pad surface and metal.

[0015]

A fibrous material such as of aramide, polyester, or polyimide is used as the organic fiber. Two or more of the fibrous materials may be used in combination as selected properly. Preferably an aramide fiber, aromatic polyamide fiber, is selected as its single or major component, and more preferably, an aramide fiber is used alone. It is because the aramide fiber is effective, because it is higher in tensile strength than other

common organic fibers and thus remains on the surface in a greater amount when the surface of the polishing pad according to the present invention is roughened mechanically for exposure of the fiber. In addition, use of it also improves the durability of polishing pad and elongates its lifetime during use.

[0016]

There are two kinds of aramide fibers, para- and meta-aramide fibers, but the para-aramide fiber is more preferable, as it is higher in mechanical strength and lower in hygroscopicity than the meta-aramide fiber. A commercially available product, poly-p-phenylene terephthalamide fiber or poly-p-phenylene diphenylether terephthalamide fiber, may be used as the para-aramide fiber.

[0017]

The usable fiber diameter of the organic fiber is 1 mm or less, preferably 200 μm or less, more preferably 1 to 200 μm, and still more preferably 5 to 150 μm. An excessively large diameter may lead to an excessively high mechanical strength, occasionally causing polishing scratch and inadequate dressing. Alternatively, an excessively smaller diameter may lead to deterioration in handling efficiency and in pad durability because of insufficient strength. The usable fiber length is 10 mm or less, preferably 5 mm or less, and more preferably 0.1 to 3 mm. An excessively shorter length may lead to lack of maintaining effectively the exposed fibers from the pad when the pad surface is roughened mechanically, while an excessively longer length may make molding of a mixture of a resin and the

fiber difficult because of increase in viscosity of the mixture. It is possible to use the short fibers chopped to a particular length, or to use a mixture of several short fibers different in length.

In addition, the fiber surface may be previously roughened mechanically or chemically modified, for example, with a coupling agent for improvement in compatibility with the resin. Bundles of chopped short fibers bound to each other as coated with an extremely small amount of resin may be used for convenience in handling. However, the resin for adhesion is added in such an amount that the short fiber is easily dispersed in the matrix resin by the heat or the shearing force applied during agitation with the matrix resin. In addition to the organic fiber, an inorganic fiber such as glass fiber may be added.

During polishing, the organic fiber exposed on the work material-sided surface retains efficiently the polishing particles (abrasive) contained in the polishing solution described below.

[0018]

The content of the organic fiber is not particularly limited, but should be optimized according to the softening temperature and the viscosity of the matrix thermoplastic resin. It is preferably 1 to 50 wt%, more preferably 1 to 20 wt%, and still more preferably 5 to 20 wt% in the pad. Decrease in the fiber content may result in significant increase in the number of polishing scratches on the polishing surface, while increase thereof in deterioration in molding efficiency.

[0019]

The method of producing the polishing pad according to the present invention includes a step of mixing a fiber containing an organic fiber with a matrix composition containing a thermoplastic resin composition to give a mixture, a step of tabletizing the mixture, and a step of converting the tablets into sheet shape by extrusion molding.

In preparing the thermoplastic resins composition according to the present invention or the other matrix composition and the method of mixing it with fiber is not particularly limited, and any known method may be used. The components for the matrix are mixed (dry-blended), for example, in a mixer such as Henschel Mixer, super mixer, tumble mixer, or ribbon blender, and the mixture is extruded in the molten state, for example, from a single screw extruder, a twin screw extruder, or a Banbury mixer.

An organic fiber is then added, and the mixture is melt-blended similarly, and then cooled into tablets. When water is used for cooling, the tablets should be dried sufficiently for dehydration.

The tablets obtained are extruded with a molding machine through a dice and rolled with a roll, to give a sheet-shaped molding. In an alternatively preparative method, injection molding in a mold may be used to give a sheet-shaped molding, instead of the extrusion molding above. Such a sheet-shaped molding is then processed as needed as it is mounted on the polishing table of a particular polishing machine according to

its shape, to give a final product polishing pad. For an example, a final product polishing pad can be prepared by cutting the sheet-shaped molding in circular shape.

The entire thickness of the polishing pad is preferably 0.1 to 5 mm, more preferably 0.5 to 2 mm. Grooves for example in the shape of concentric circles or lattice may be formed on the polishing surface of the pad by using a NC lathe.

[0020]

In the present invention, the fiber on the work material-side surface of the pad is exposed as needed to obtain a polishing pad having at least its organic fiber exposed on the work material-sided surface. One of the methods of forming the fiber-exposed layer is dressing treatment, a method of exposing the fiber by scraping off the pad surface by using a whetstone such as diamond powder. Other material such as wire brush, metal scraper, resin brush, or glass or ceramic plate may be used instead of the whetstone. The length of the organic fiber in the region exposed on the surface is generally 1 mm or less for usable practical reason, but preferably 200 μm or less, more preferably 1 to 200 μm, and still more preferably 10 to 150 μm. An excessively short length leads to deterioration of the retaining stability of polishing slurry, while an excessively long length to adverse effect on flatness.

[0021]

Hereinafter, polishing methods by using the polishing pad according to the present invention will be described. The first polishing method according to the present invention is

characterized by pressing the polishing surface of a base material to the organic fiber-exposed face of the polishing pad according to the present invention (i.e., work material-sided face) and sliding the base material and the polishing pad relatively to each other while supplying a polishing slurry between the polishing surface and the pad.

Here, at least part of a metal film is preferably removed by polishing a single-layered or multi-layered metal film as the polishing surface.

Examples of the metal to be polished in the present invention include, copper, alloys containing mainly copper, the compounds thereof such as oxides and nitrides, and the like. Also included are metals other than copper such as tantalum, tungsten, and aluminum, the alloys thereof, the compounds thereof such as oxides and nitrides, and the like. The metal to be polished preferably contains at least one compound selected from the group consisting of copper, copper alloys, copper oxides, and copper alloy oxides (hereinafter, referred to as copper and the compounds thereof). When the metal to be polished is a laminate film, it is a laminated film in combination of the layer to be polished first that is made of at least one compound selected from the copper and the compounds thereof and the layer to be laminated with the layer, i.e., the next layer, that is made of at least one compound selected from tantalum and the compounds thereof, titanium and the compounds thereof, and tungsten and the compounds thereof. The layer at least part of which is removed by polishing is preferably the layer to be polished first.

[0022]

The base material having a polishing surface is, for example, a substrate having an interlayer insulation film having viaholes and trenches formed by dry etching in the wiring process during production of semiconductor devices, a barrier film completely covering the openings and internal walls, and a metal film filling the openings completely such as of Cu formed thereon by growth. A desirable metal wiring pattern is obtained, as the metal film in the convex area is polished selectively and the metal film is left in the concave area.

[0023]

Thus, the second polishing method according to the present invention is characterized by including a first polishing step of polishing at least metal layer of a substrate having an interlayer insulation film consisting of concave area and convex area on the surface, a barrier conductor layer covering the interlayer insulation film along the surface, and the metal layer filling the concave area and covering the barrier conductor layer, and exposing the barrier conductor layer in the convex area, and a second polishing step of polishing at least the barrier conductor layer and the metal layer in the concave area and exposing the interlayer insulation film in the convex area after the first polishing step, wherein the polishing pad according to the present invention is used for polishing at least in the second polishing step.

[0024]

The barrier conductor layer (hereinafter, referred to as

barrier layer) is preferably a barrier layer to the metal layer, in particular to a copper or copper alloy layer. The barrier layer is formed for prevention of diffusion of the metal layer into the insulation film and improvement in adhesion between the insulation film and the metal layer. Examples of the materials for the conductive layer include tantalum, titanium, tungsten, the compounds thereof such as nitrides, oxides and alloys, and the like.

The metal layer covering the barrier layer is, for example, a film having a metal, such as copper or the compound thereof, tungsten, tungsten alloy, silver, or gold described above, as its principal component, and a film containing copper or the compound thereof as its principal component is preferable. A film of such a material prepared by a known method such as sputtering or plating is used favorably as the metal layer.

[0025]

Examples of the interlayer insulation films include silicon film and organic polymer films. Examples of the silicon films include films such as of silicon dioxide, fluorosilicate glass, and an organosilicate glass prepared by using trimethylsilane or dimethoxydimethylsilane as the starting material, and silica-based films such as of silicon oxynitride and hydrogenated silsesquioxane, silicon carbide and silicon nitride. An example of the organic polymer film is a wholly aromatic low-dielectric interlayer insulation film. In particular, the interlayer insulation film preferably has a dielectric constant of 2.7 or less.

Such a film is formed, for example, by CVD, spin coating, dip coating, or spraying.

[0026]

The CMP polishing slurry for use in the present invention is not particularly limited, and examples thereof include Cu polishing slurries such as polishing particles of silica, alumina, ceria, titania, zirconia and germania, and polishing slurries prepared by adding an additive and an anticorrosive as well as a peroxide to water. Colloidal silica or alumina particles are particularly favorable as the polishing particle. The content of the polishing particles is preferably 0.1 to 20 wt%. The polishing particles may be prepared in any way, but the average diameter is preferably 0.01 to 1.0 μm. A polishing particle having an average diameter of less than 0.01 μm leads to decrease in polishing speed, while that of more than 1.0 μm causes an increased number of scratches.

[0027]

The polishing machine for use is not particularly limited, and, for example, a disk polishing machine or a linear polishing machine may be used. For example, common polishing machines having a holder for holding a work material and a polishing table for connection to a polishing pad that is connected to a variable frequency motor may be used. An example thereof is a polishing machine EP0111, manufactured by Ebara Corporation.

[0028]

For connection of the polishing pad above to the polishing table of polishing machine, an adhesive such as double-faced

adhesive tape may be used on the face of the pad opposite to the polishing surface. Alternatively, it may be connected with a low-modulus subpad, for example, of formed polyurethane.

Typically, to polish a work material by pressing its polishing surface to a polishing pad and sliding the polishing pad relatively to the work material, at least one of the work material and the polishing table is moved. Polishing may be performed by rotation or reciprocating motion of the holder, instead of rotation of the polishing table. Other examples include polishing methods of revolving polishing tables planetarily and moving a belt-shaped polishing pad linearly in the longitudinal direction, and the like. The holder may be fixed, rotated, or moved reciprocally. The polishing method is not particularly limited, if it can move the polishing pad and the work material relatively to each other, but should be selected properly according to the work material's polishing surface and the polishing machine used.

The polishing condition is not particularly limited, and preferably optimized according to the work material. For example, the rotational velocity of the polishing table is preferably lower at 200 rpm or less so that the base material will not be spun off, and the pressure applied to the work material is preferably lower, for example at about 50 kPa or less, when the work material's polishing surface is copper, for prevention of generation of scratches during polishing. In addition, the pressure is preferably 20 kPa or less when a work material having a low-dielectric constant interlayer insulating film is used.

A polishing solution is supplied continuously, for example, by a pump between the polishing pad and the work material's polishing surface during polishing. The feed rate is not limited, but the surface of the polishing pad is preferably covered always with the polishing solution. The pad and the exposed organic fiber degenerated by polishing are regenerated and preserved by dressing.

The work material after polishing is preferably washed thoroughly with running water and dried after the water drops on the polishing surface are removed, for example, by using a spin dryer.

[0029]

Hereinafter, favorable embodiments of the polishing method according to the present invention will be described taking wiring layer formation in production of semiconductor devices as an example.

First, an interlayer insulating film, for example of silicon dioxide, is laminated on a silicon substrate. The interlayer insulating film surface is then converted to an interlayer insulating film having a surface irregularity by forming concave area in a certain pattern (substrate exposed areas) by any one of known means such as resist layer formation or etching. A barrier layer, for example of tantalum, is deposited, for example, by vapor deposition or CVD along the surface irregularity on the interlayer insulating film. Further, a metal layer, for example of copper, covering the barrier layer is formed for example by vapor deposition, plating,

or CVD, filling the concave area in the barrier layer. Preferably, the thickness of the interlayer insulation film, the barrier layer and the metal layer formed are respectively, approximately 0.01 to 2.0 μm, 1 to 100 nm, and 0.01 to 2.5 μm.

[0030]

Then, the metal layer on the surface of substrate is polished by CMP by using the polishing pad according to the present invention while a polishing solution (first polishing step) is supplied. Thus, the barrier layer in the convex area of the substrate is exposed on the surface, giving a desired wiring pattern that still retains the metal film in the concave area. Part of the barrier layer in the convex area may be polished together with the metal layer during the polishing.

[0031]

In the second polishing step, at least the exposed barrier layer and the metal layer in concave area are polished by CMP, by using a polishing solution allowing polishing of the metal, barrier and interlayer insulating layers. The polishing is terminated when the interlayer insulating film under the convex barrier layer is exposed entirely, the metal layer for wiring layer is left in the concave area, and a desired pattern in which the cross sectional area of the barrier layer is exposed at the boundary of convex area and concave area is obtained. The polishing pad according to the present invention is used at least in the second polishing step, but preferably used also in the first polishing step, as shown in this embodiment.

For ensuring the superiority in flatness after polishing,

it may be over-polished (e.g., if a desired pattern is obtained within 100 seconds in the second polishing step, polishing additionally for 50 seconds is called 50% over-polishing) to a depth including part of the convex interlayer insulating film.

[0032]

After metal wirings are performed on the interlayer insulation film and the second layer laminated on the metal wiring thus formed and interlayer insulation films are formed between the wirings and over the wiring, the entire surface of the semiconductor substrate is polished. It is possible to produce a semiconductor substrate having a desired number of layers, by repeating the steps above several times.

[0033]

The polishing pad according to the present invention and the polishing method using the same are applicable not only to the films containing mainly a metal such as Cu, Ta, TaN or Al filled in the composite openings of an insulation layer, but also to inorganic insulation films formed on a particular wiring board such as of silicon oxide film, glass, and silicon nitride, films mainly containing polysilicon, optical glasses such as photomask, lens and prism, inorganic conductive films such as of ITO, optical single crystals of glass or a crystalline material such as optical integrated circuit, optical switching element, end face of optical waveguide, optical fiber, and scintillator, solid state laser single crystals, sapphire substrates for blue laser LED, semiconductor single crystals of SiC, GaP, and GaAs, glass or aluminum substrates for magnetic disk, and magnetic

heads, and the like.

[0034]

[Example]

Hereinafter, the present invention will be described in detail with reference to Examples, but it should be understood that the present invention is not restricted by these Examples.

(Example 1)

An organic fiber, poly-p-phenylene terephthalamide fiber (trade name "Kevlar", manufactured by Dupont, fiber diameter: 12.5 μm, fiber length: 3 mm) and a matrix composition, ABS resin pellet were melt-blended and tabletized in an extrusion molding machine. The content of the poly-p-phenylene terephthalamide fiber was adjusted to 10 wt%. The tablet obtained was dried in a large-sized dryer at 120°C for 5 hours, and then processed into a sheet-shaped molding of 1.2 mm in thickness and 1 m in width by using an extrusion molding machine and a roll. The sheet was cut into circular form, and then, grooves having a cross section in a rectangular shape having a depth of 0.6 mm and a width of 2.0 mm were formed in the grid pattern at a pitch of 15 mm. In addition, a double-sided adhesive tape was bonded to the face opposite to the face whereon the grooves were formed, and it was used as a polishing pad.

[0035]

(Example 2)

A polishing pad was prepared in a similar manner to Example 1, except that a mixture of polyethylene, polypropylene, and a styrene elastomer at a ratio of 50:50:100 by weight is used

as the matrix composition.

[0036]

(Example 3)

A polishing pad was prepared in a similar manner to Example 1, except that polypropylene was used as the matrix composition.

[0037]

(Comparative Example 1)

A polishing pad was prepared in a similar manner to Example 1, except that no organic fiber was used.

(Comparative Example 2)

A formed polyurethane polishing pad was prepared.

Each of the following five kinds of pads was connected to the polishing table of a polishing machine and surface-roughened by using a dresser with #160 diamond whetstone for 30 minutes.

[0038]

(Preparation of polishing slurry)

A polishing particle-free polishing slurry (trade name: HS-C430 slurry, manufactured by Hitachi Chemical Co., Ltd.) and the same polishing slurry containing colloidal silica having an average secondary particle diameter of 35 nm at a concentration of 0.37 wt% were used as polishing slurries for copper. Both polishing slurries were blended with a hydrogen peroxide solution at a rate, polishing solution:hydrogen peroxide solution, of 7:3 before use.

[0039]

(Polishing of substrate)

Silicon wafer substrates (hereinafter, referred to as wafers) with and without wiring were polished as follows by using the polishing pads prepared in Examples and Comparative Examples and the polishing solution prepared above, and the polishing speed, the polishing scratch, and the dishing, an indicator of flatness, were examined.

The wafer was connected to the holder with an adhesive pad for attaching wafer in the polishing machine. Each of the polishing pads prepared in Examples and Comparative Examples was adhered to the polishing table of the polishing machine, and the holder having a work material with its polishing surface facing downward was placed on it in the polishing machine. The work material's polishing surface was polished under an applied load of 4×10^4 Pa, while the polishing solution is supplied at a flow rate of 150 cc/min and the polishing table and the wafer were rotated at a frequency of 38 rpm; and the results are summarized in Table 1.

[0040]

(Evaluation of polishing speed)

A silicon wafer substrate (diameter: 13 cm) having a silicon dioxide film layer without wiring and a copper film of 1 μm in thickness formed thereon was polished for 2 minutes. The thicknesses of the copper film before and after polishing were determined by measuring the sheet resistivity with a resistivity meter RT-7 manufactured by Napson Corporation and calculating the film thickness from the resistivity, and the difference between the film thicknesses before and after CMP

was determined. Results are summarized in Table 1.

[0041]

(Evaluation of polishing scratch)

The number of the scratches on the wafer used for evaluation of polishing speed was counted by visual observation. Results are also summarized in Table 1.

○: Less than five scratches on the work material's polishing surface after polishing

×: Five or more scratches on the work material's polishing surface after polishing

[0042]

(Dishing amount)

A silicon substrate (diameter: 13 cm) having a surface shape in the striped pattern consisting of wiring metal (copper) areas of 100 μm in width and insulation film (silicon dioxide) areas of 100 μm in width that are formed alternately was prepared as a work material, by forming a silicon dioxide film having a thickness of 300 nm on a silicon wafer, forming trenches having a depth of 0.5 μm on the silicon dioxide film at a wiring density of 50% by a known sputtering method, forming a tantalum nitride film having a thickness of 50 nm as a barrier layer, forming a copper film of 1.0 μm in thickness similarly by sputtering, and embedding it by a known heat treatment.

The work material was subjected to two-step polishing, polishing of copper film and of barrier layer, and the decrease in the amount of film in wiring metal area from that in the insulation film area was determined from the surface shape in

the stripe-patterned area, by using a stylus profilometer (Dektat3030, manufactured by Veeco/Sloan). Results are also summarized in Table 1. "No measurement possible" in the Table, means that the substrate could not be polished at low polishing speed or that there were too many polishing scratches prohibiting measurement.

[0043]

Polishing pads prepared in Example 1 and Comparative Example 1 have the same matrix resin and differ from each other in whether the substrate contains fiber. The polishing pad of Example 1 according to the present invention is resistant to generation of scratches and thus superior to the pad of Comparative Example 1 containing no organic fiber. The pad of Comparative Example 1 gave a greater number of polishing scratches, which prohibited dishing measurement. In the Examples above, use of a polishing particle-free polishing slurry almost prohibited polishing, and thus, the polishing mechanism in the Examples is obviously different from that in Comparative Example 1 or 2, which is higher in polishing speed.

[0044]

[Table 1]

Pad	Polishing particle in Polishing slurry	Polishing speed (Å/min)	Scratch	Dishing (Å)
Example 1	Free	50	○	No measurement possible

	Containing	1000	○	300
Example 2	Free	70	○	No measurement possible
	Containing	1000	○	300
Example 3	Free	40	○	No measurement possible
	Containing	800	○	300
Comparative Example 1	Free	1000	×	No measurement possible
	Containing	1500	×	No measurement possible
Comparative Example 2	Free	2200	○	500
	Containing	2500	○	1100

[0045]

Then, a polishing test was performed in a similar manner to the test above, except that a polishing particle-containing polishing slurry, which was higher in polishing speed, was used from the results above and a processing load of 2×10^4 Pa was applied. Results are summarized in Table 2. As apparent from Table 2, there was almost no difference between the polishing speeds in Examples and the Examples under the polishing conditions above, indicating that it was possible to polish even under a low load, i.e., under a low friction force. On the other hand in Comparative Examples, the polishing speed decreased drastically under low load, for example, under the current condition.

[0046]

[Table 2]

Pad	Polishing speed (Å/min)	Scratch	Dishing (Å)
Example 1	700	○	300
Example 2	700	○	300
Example 3	700	○	300
Comparative Example 1	400	×	No measurement possible
Comparative Example 2	100	○	600

[0047]

Accordingly, it is possible to reduce the load applied to the insulating layer during CMP and improve the flatness of the polished film by using the polishing pad according to the present invention.

[0048]

[Effect of the Invention]

According to the present invention, it is possible to perform CMP polishing at low load, to polish metal with smaller load to the interlayer insulation film for example in production of a semiconductor device while giving a polished product superior in flatness, and thus, to perform the next-generation dual damascene method easily.

[Name of Document] Abstract

[Abstract]

[Object] The present invention provide a polishing pad that is superior in flatness, has smaller load, and allows polishing without defects in the insulation layer, in the CMP method, by which wiring is formed by embedding and growing a metal film into a trench pattern formed on an interlayer insulation film and flattening the metal film by polishing, and a polishing method using the same.

[Solving Means] A polishing pad, comprising a fiber including an organic fiber and a matrix resin holding the fiber inside, wherein at least the organic fiber is exposed on the work material-sided surface of the polishing pad and the matrix resin contains at least one thermoplastic resin.

[Selected Figure] None